



Trajectory-enhanced AIRS observations of environmental factors leading to tornadogenesis

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Long history of 'proximity sondes' to assess environmental differences that might select between different categories of severe storm events

Brooks et al., 1994; Rasmussen and Blanchard, 1998; Doswell and Evans, 2003; Thompson et al, 2003; 2012; etc.

Previous studies show higher CAPE, higher boundary layer RH, lower CIN, lower LCL, and lower LFC for **tornadic** supercells

Also notable differentiation by hail size and tornado EF scale

Efforts to use surface- or satellite-based hyperspectral IR remote sensing as 'proximity sondes' a mixed success

CAPE from Atmospheric Infrared Sounder (AIRS) underestimated, but CIN closer to radiosondes (Botes et al., 2012, JGR)

CAPE from AIRS unbiased compared to radiosondes if retrieved surface temperature replaced with surface observation (Gartzke et al., 2017, JAMC)

Rapid pre-convective evolution of CAPE & CIN with Atmospheric Emitted Radiance Interferometer (AERI) (Feltz and Mecikalski, 2002, WF)

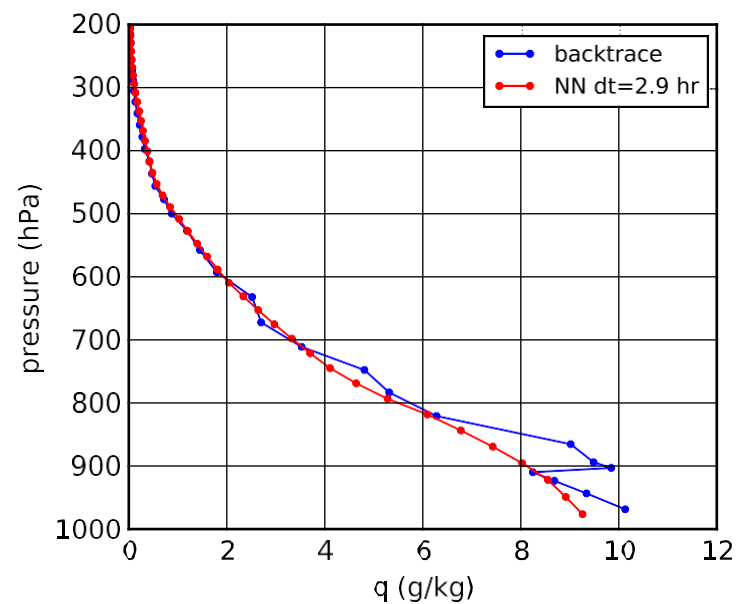
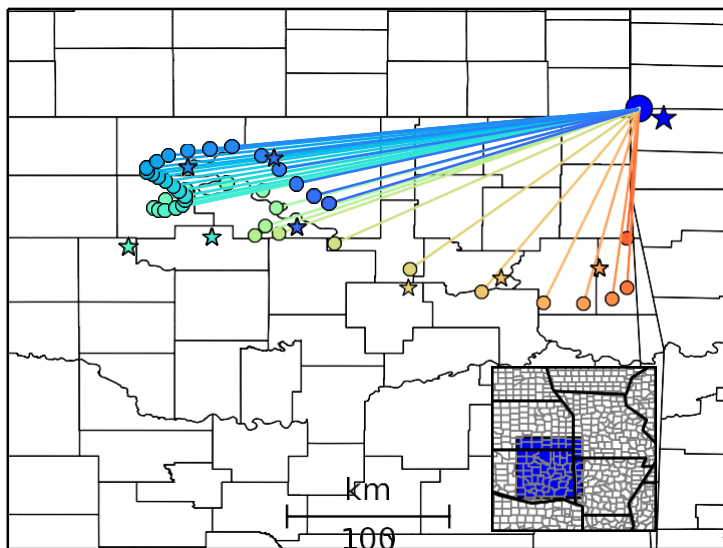
Differentiation between tornadic and non-tornadic supercells using AERI (Wagner et al., 2008, WF)

Satellite-based hyperspectral IR observations from AIRS, CrIS, and IASI
have untapped potential

Our hypothesis is that time component very substantial and
could be accounted for using trajectory modeling

Match Storm Prediction Center (SPC) storm reports to AIRS swath
observations (tornado EF scale, hail $\geq 2''$, wind gusts ≥ 65 kts)

Move backwards in time from storm report to AIRS swath



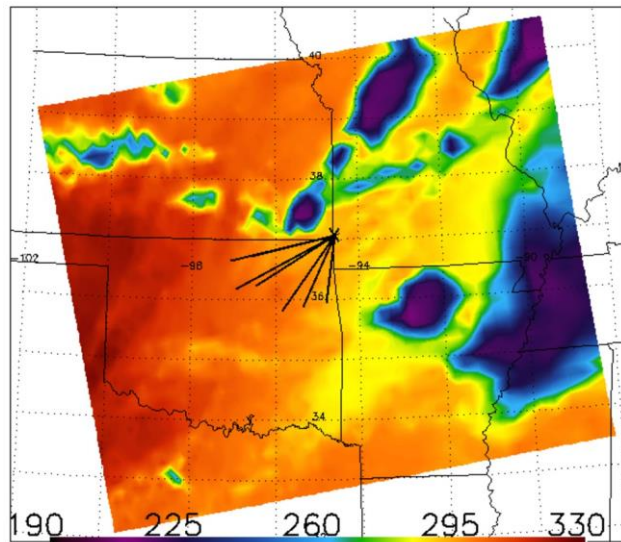
“backtrace” method using HYSPLIT forced with 32-km NARR and 12-km NAM, parcels follow dry/moist adiabats

HYSPLIT run at 40 levels; parcel traces matched to nearest AIRS 130 pm overpass; T and q profiles created from AIRS matchups

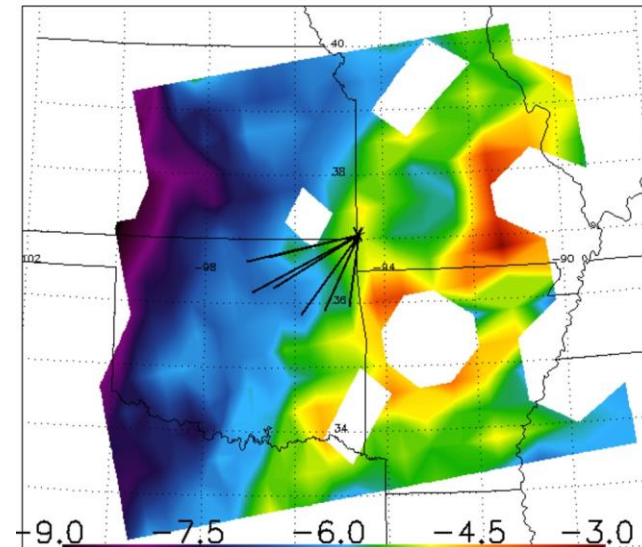
Calculate convective indices using both pyMeteo and SHARPPy

Of ~26,000 storm reports ~7% have NN and backtrace at all 40 levels

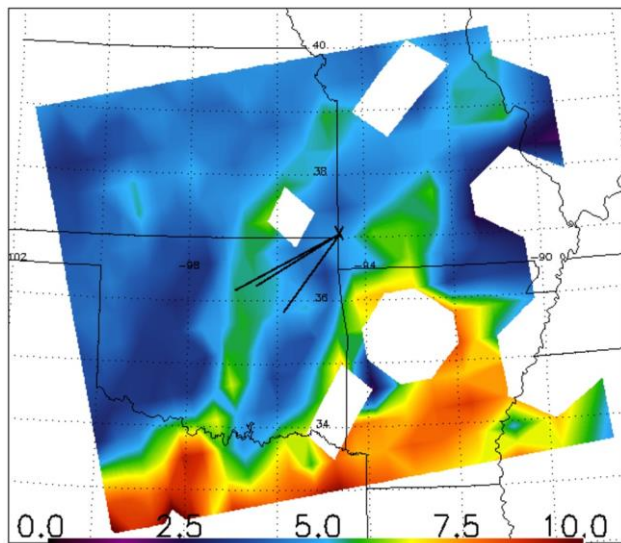
130 pm overpass before Joplin EF5 tornado (5/22/11)



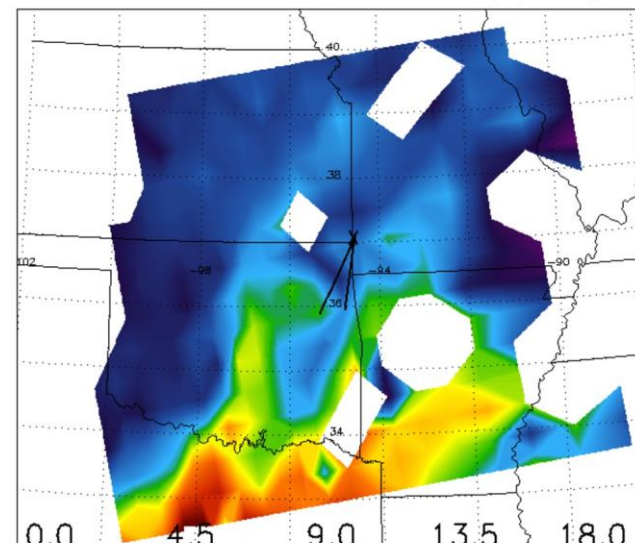
T_b at 1231 cm^{-1} (K)



925–700 hPa Lapse Rate (K/km)



H_2O mixing ratio (g/kg) at 850 hPa



H_2O mixing ratio (g/kg) at 925 hPa

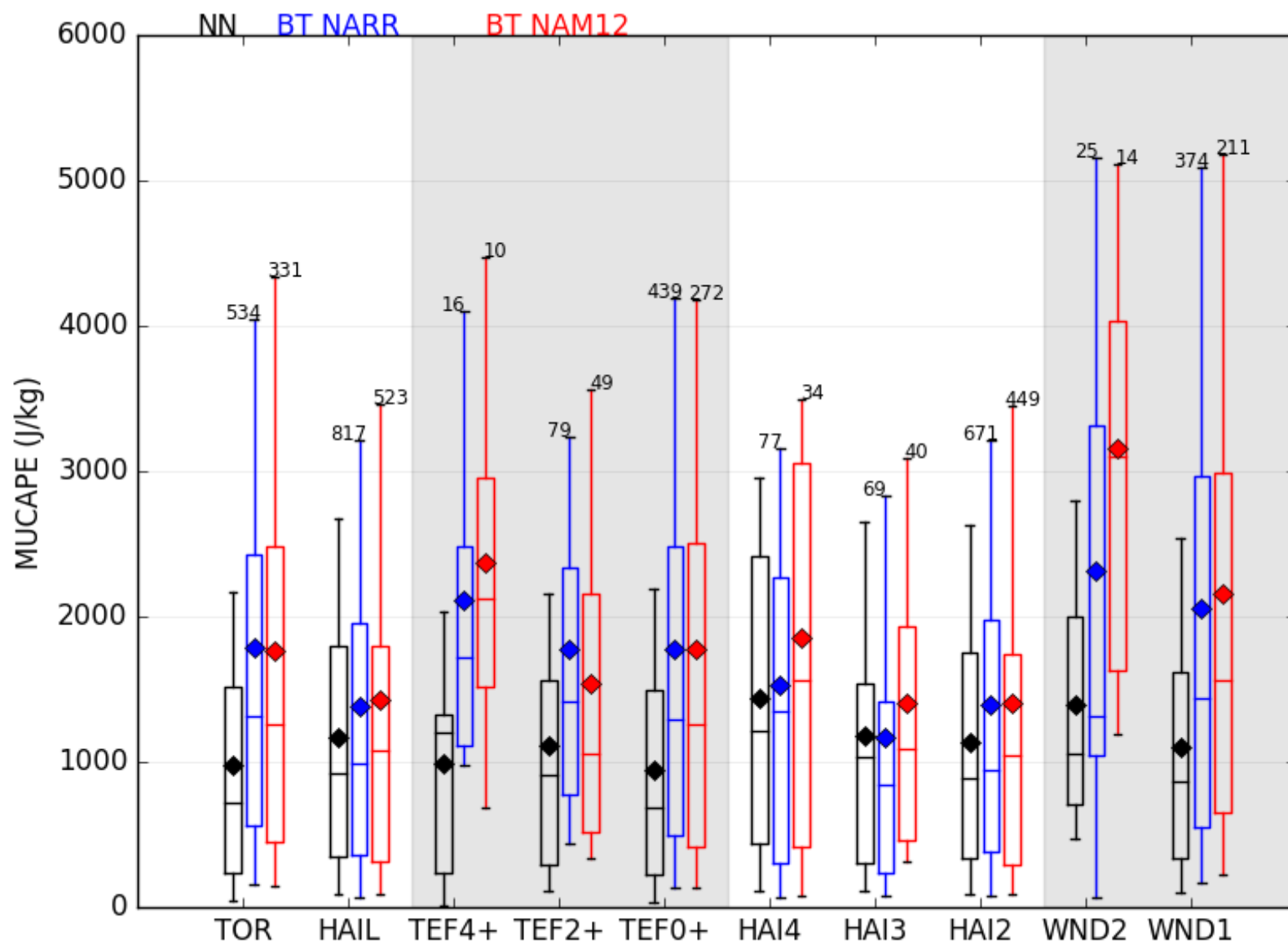
Kalmus et al., 2018, submitted

CAPE 2x enhancement in backtrace method
compared to NN for tornadoes and strong winds

Much less of an effect for large hail

CAPE using NAM slightly greater than NARR

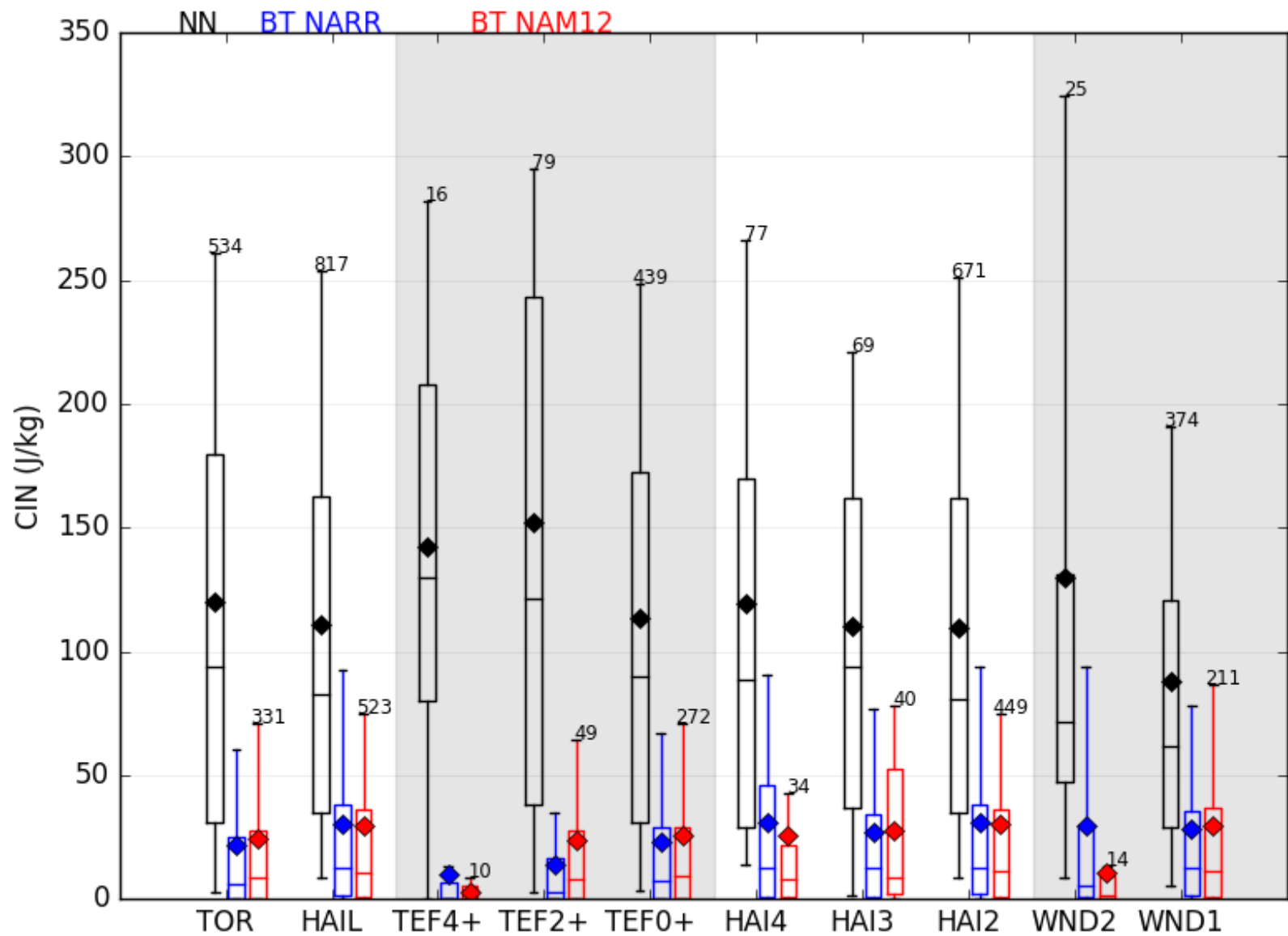
AIRS CAPE



CIN reduced greatly in backtrace method
compared to NN

CIN using NAM and NARR very similar

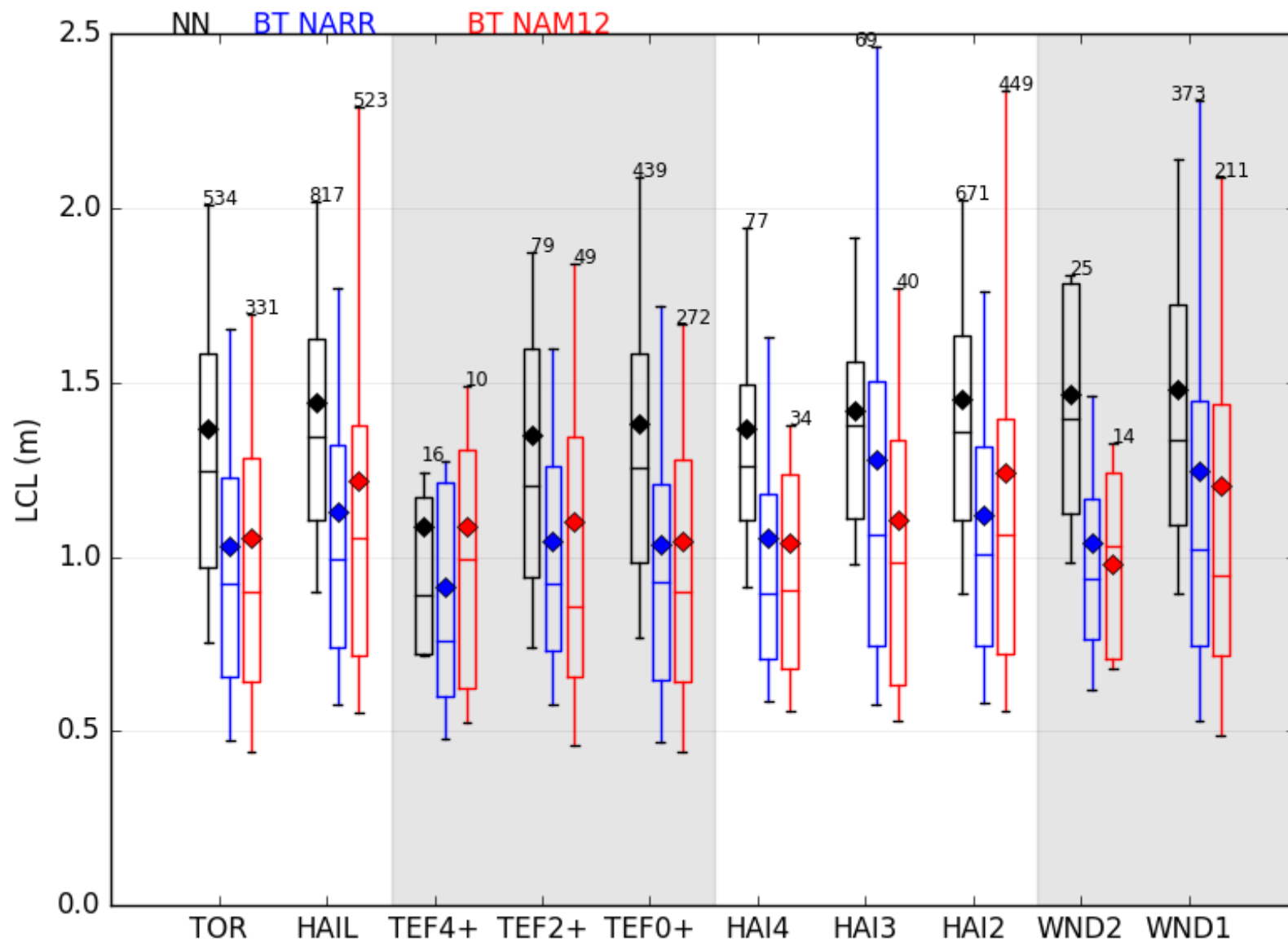
AIRS CIN



LCL lowered 300-400 m in backtrace method
compared to NN

LCL using NAM and NARR very similar

AIRS LCL

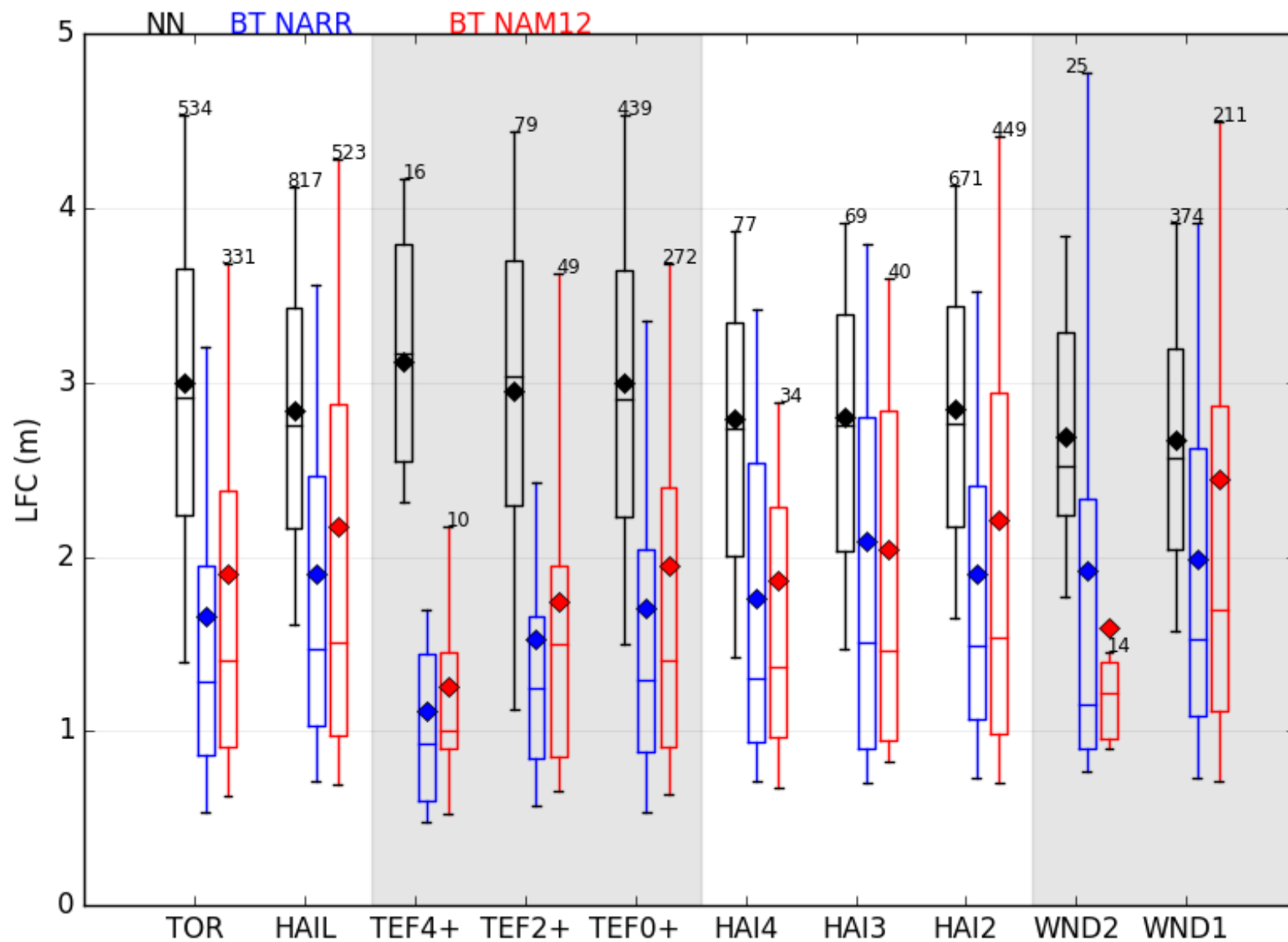


LFC lowered 1-2 km in backtrace method
compared to NN

Several hundred meter differentiation for weak,
strong, and violent tornadoes

LFC using NAM ~200 m higher than NARR

AIRS LFC

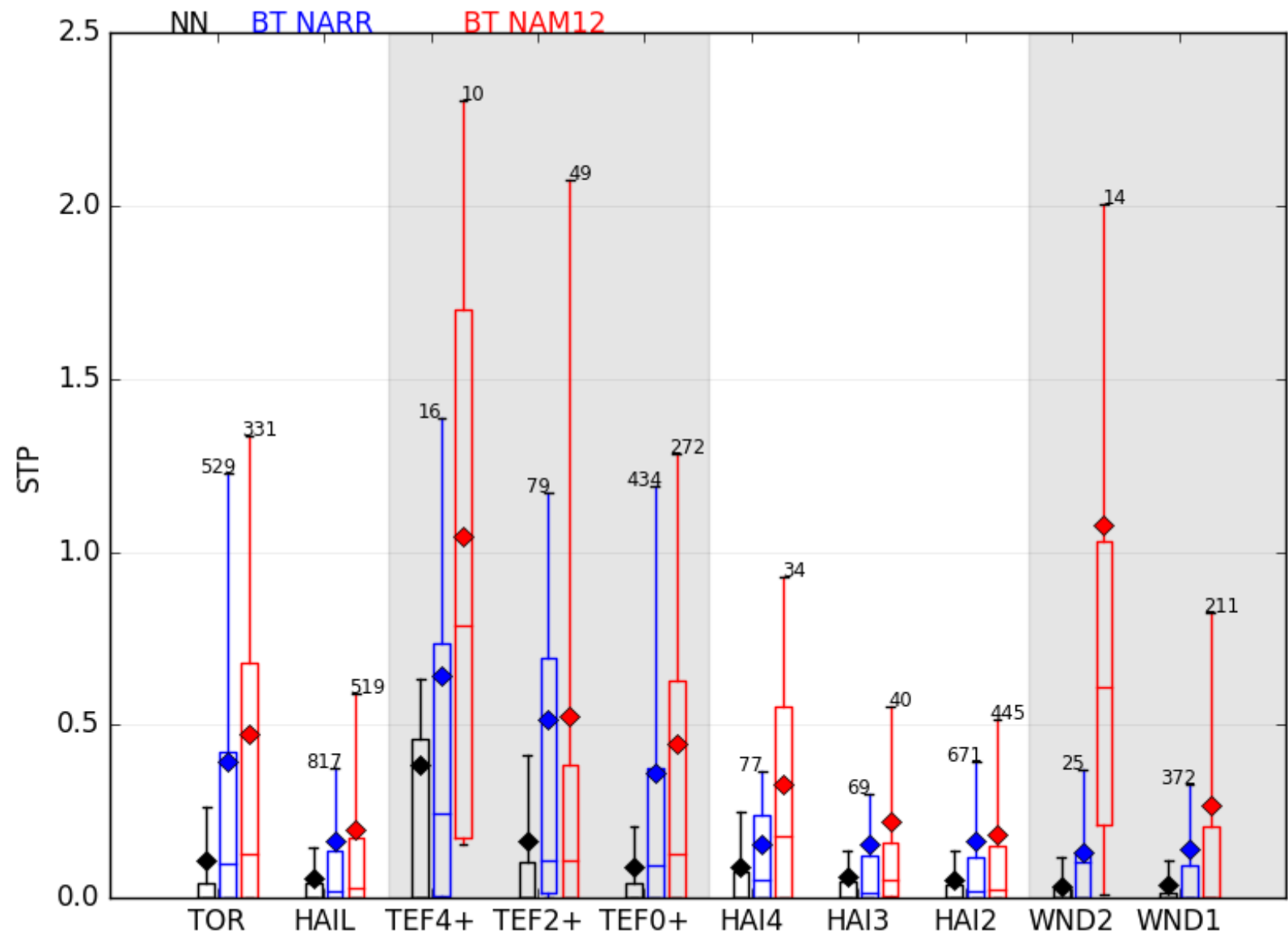


Significant tornado parameter (STP) substantially enhanced for strong/violent tornadoes in backtrace method compared to NN

STP using NAM more enhanced than NARR (NAM higher resolution in space/time)

[Effective layer STP, Thompson et al., 2012]

Significant Tornado Parameter (STP)

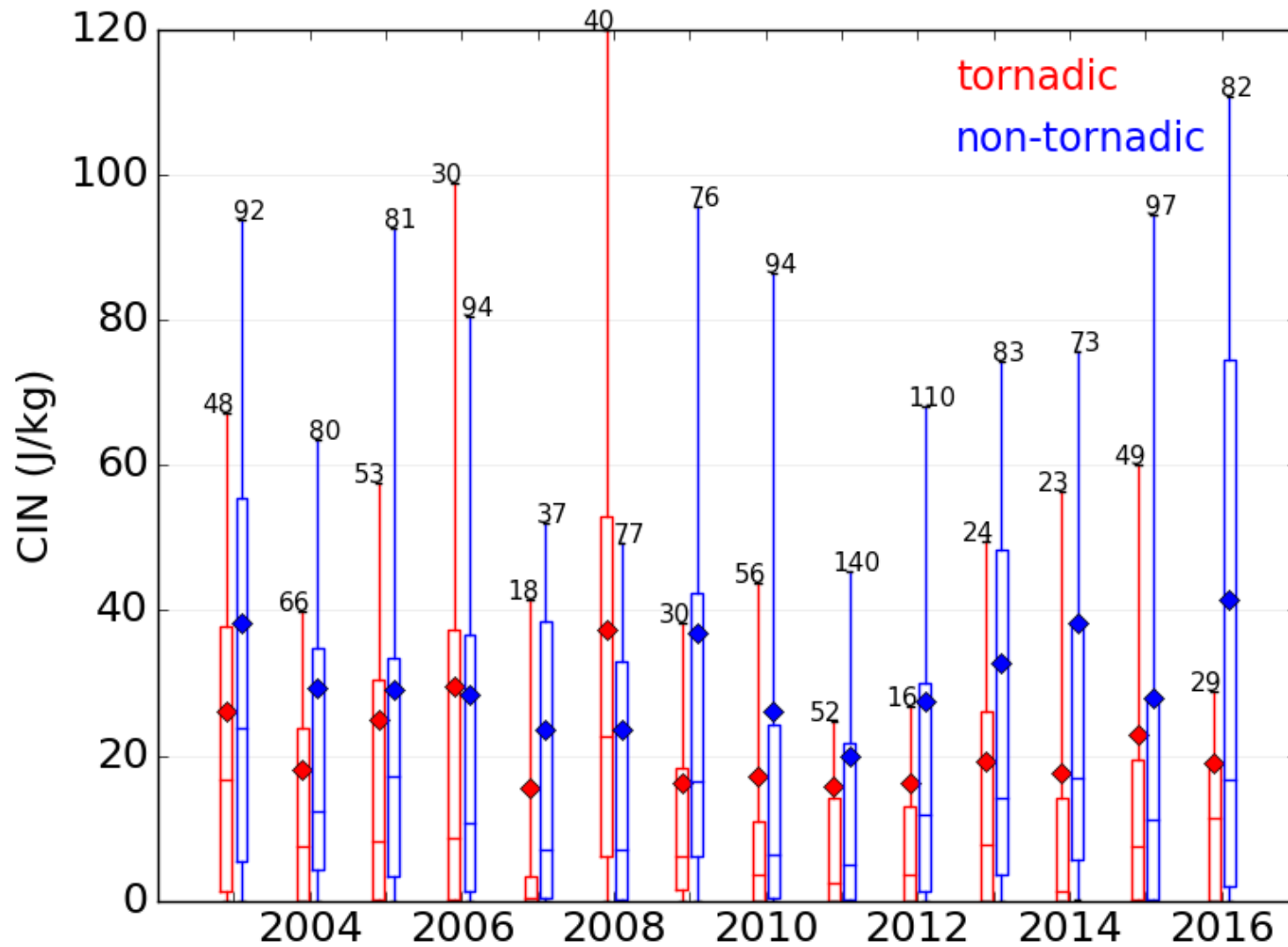


Year-to-year variability in convective parameters

Following is example for CIN

12 out of 14 years show CIN lower
for tornadic storms

Annual variability in CIN



Accounting for time variability in AIRS soundings with HYSPLIT
produces much more realistic convective indices

CAPE 2x as large; separation within tornado categories largest;
wind, hail separation less

CIN, LCL, and LFC reduced with good separation within
EF scale for LFC

STP shows improved differentiation; better for NAM than NARR

Extend to large swaths of sounding data; expand to other regions around globe; continuity with AIRS, CrIS, IASI

Context with climate variability & climate change; larger areas/time windows of favorable indices? Covariability of CAPE, CIN, shear?

What is new about tornadic/non-tornadic supercells?

Results appear to confirm earlier studies

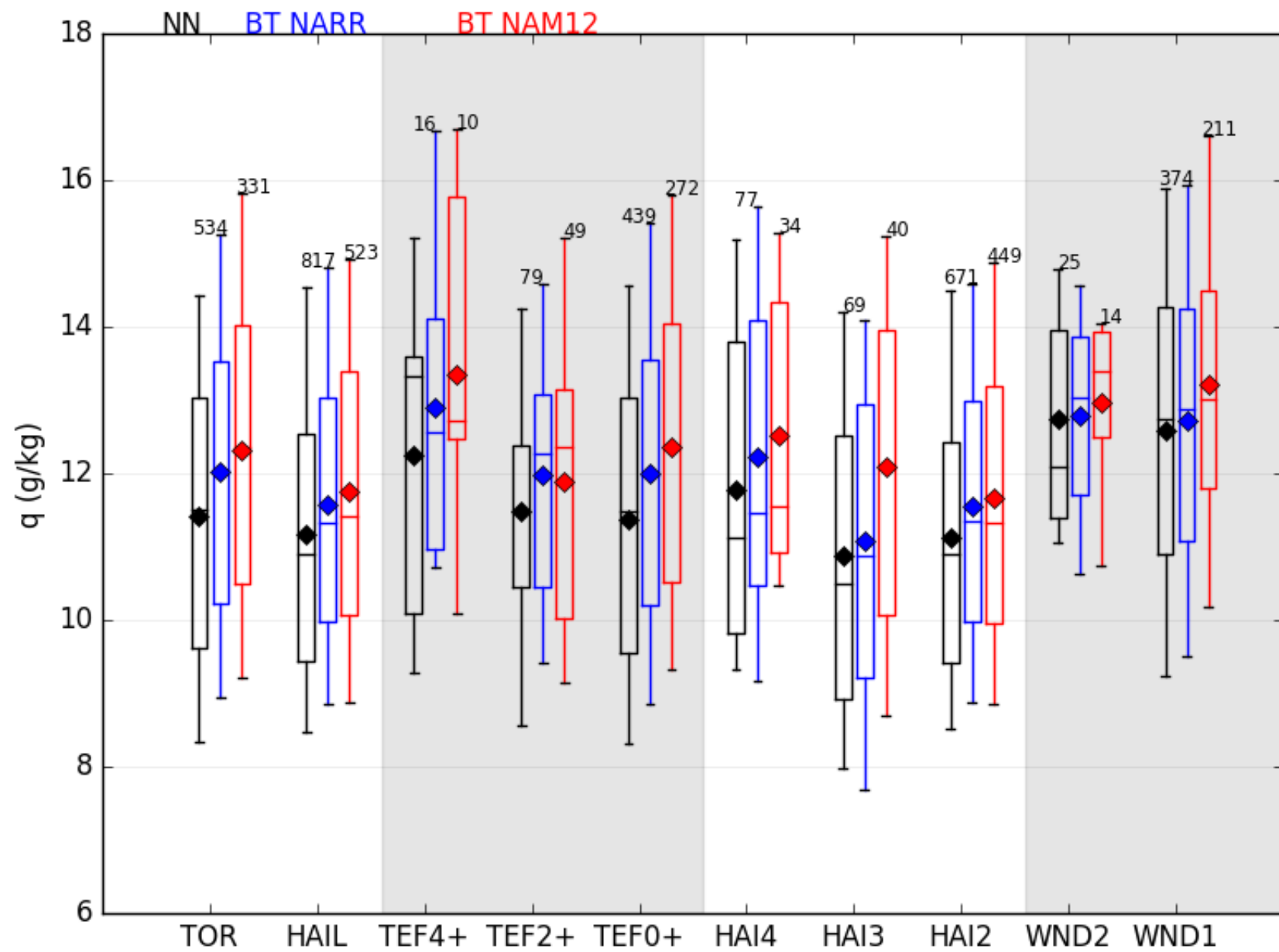
Better separation in LFC rather than LCL, however

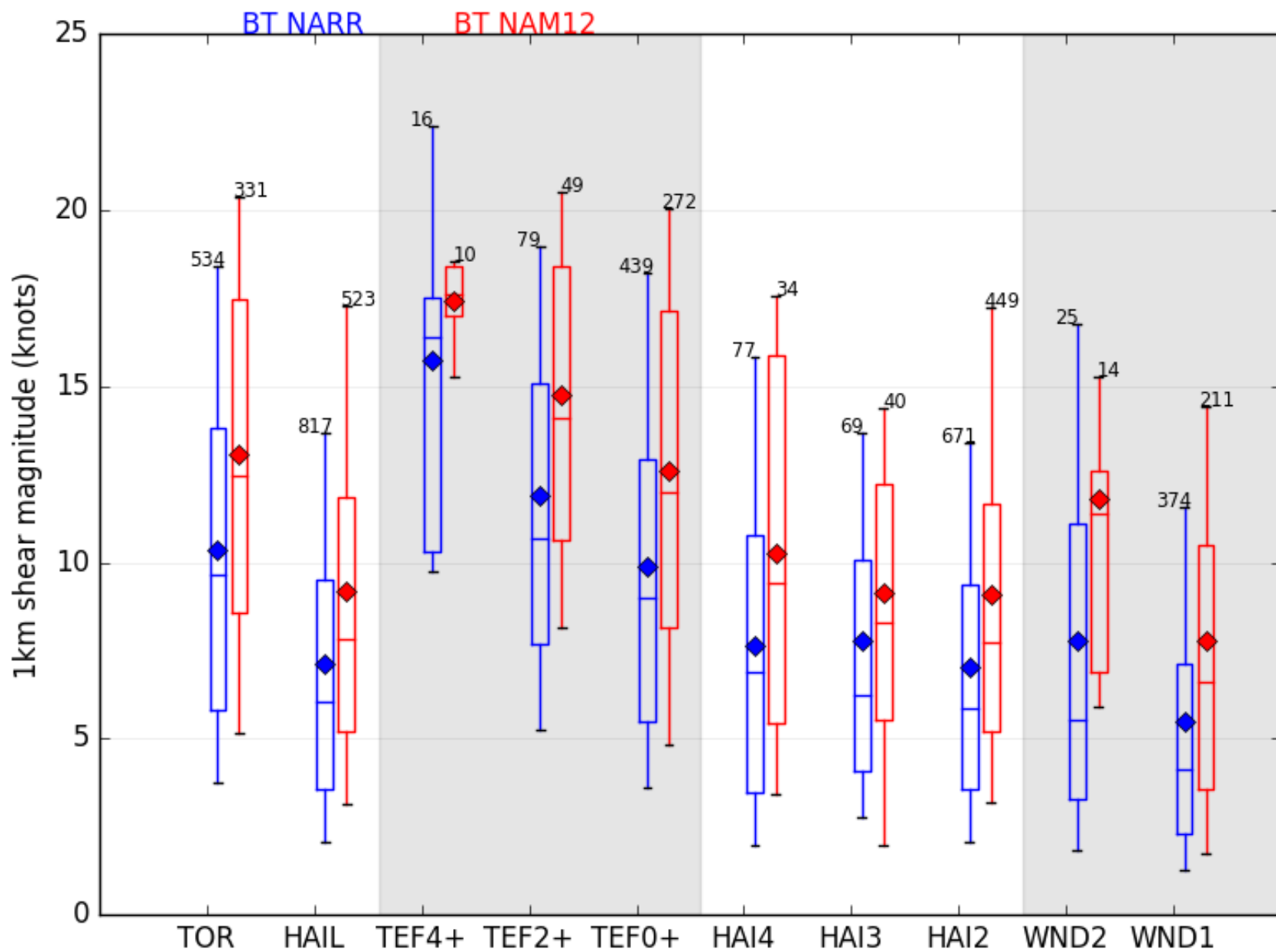
Tornadic storms appear to have much more rapid time changes

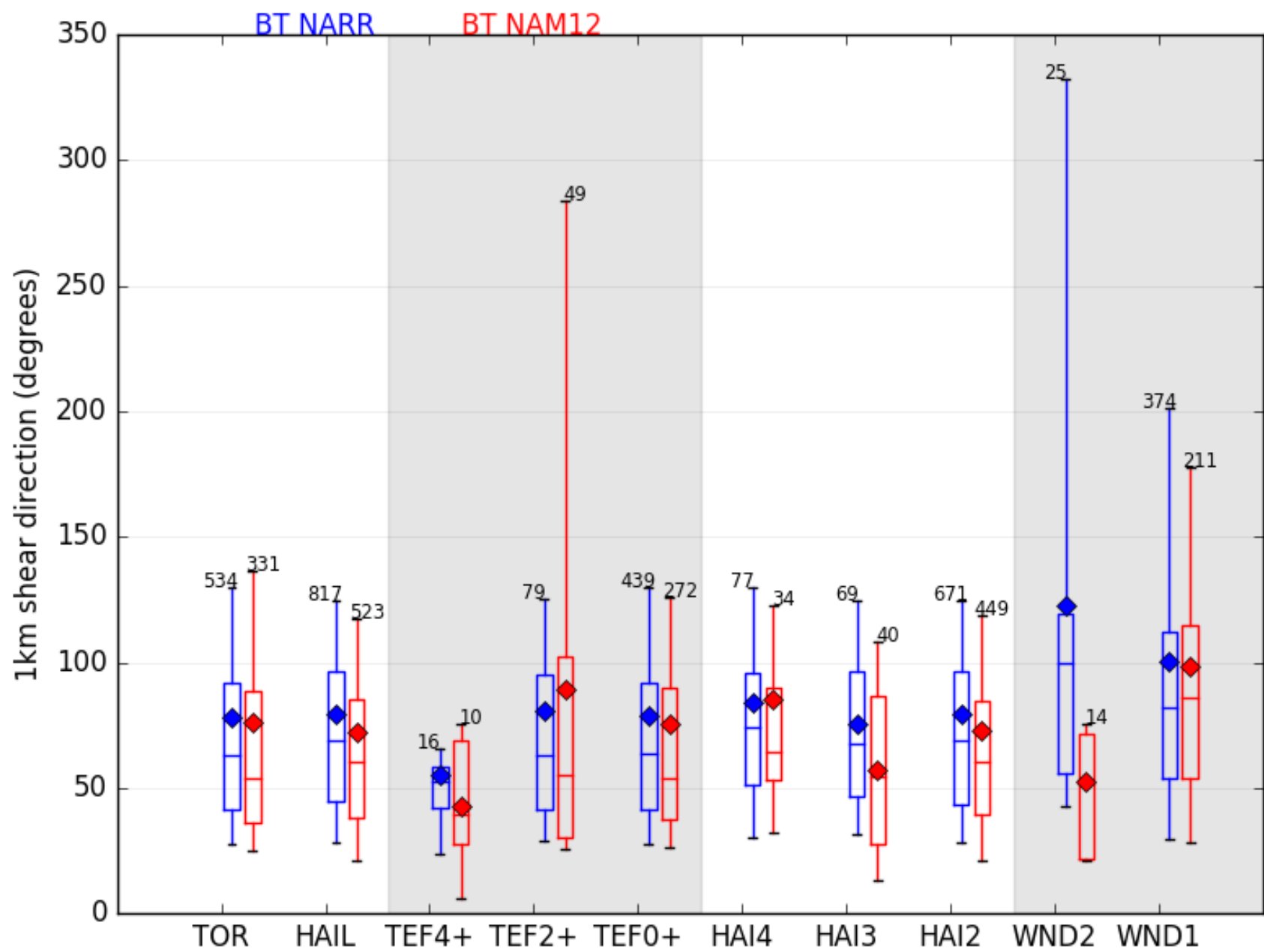
Future work: support modeling

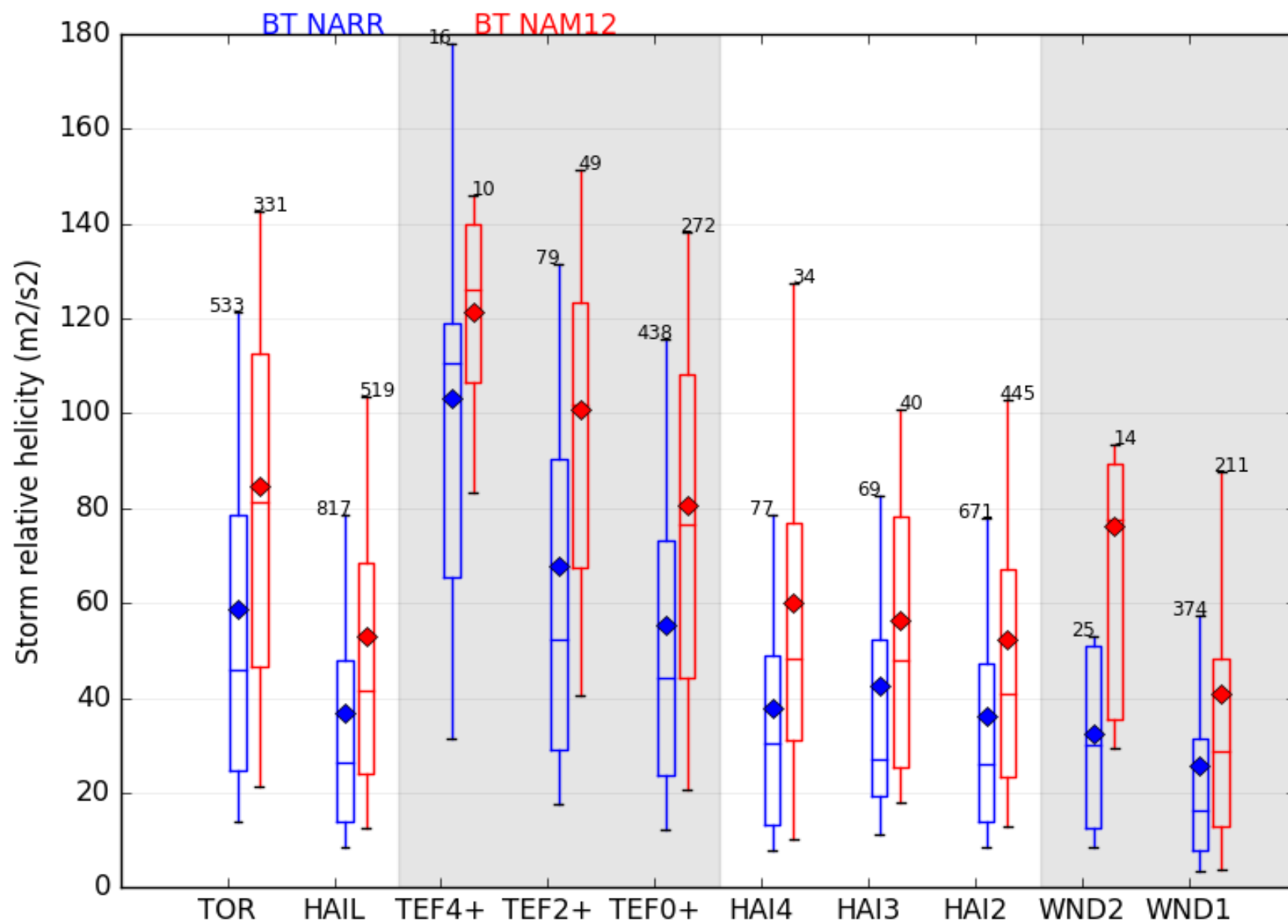
Future work: improve forecasts

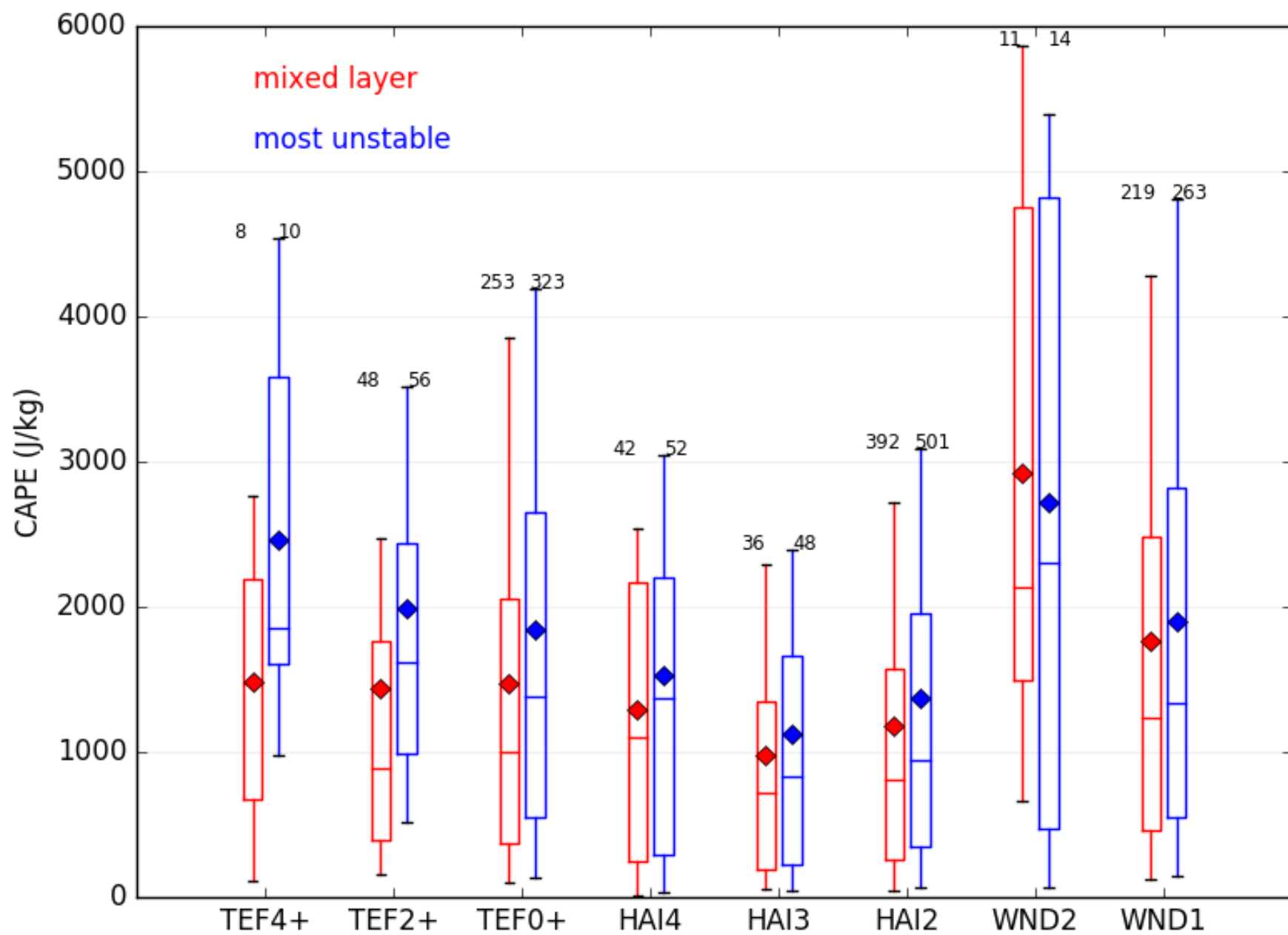
Backup Slides

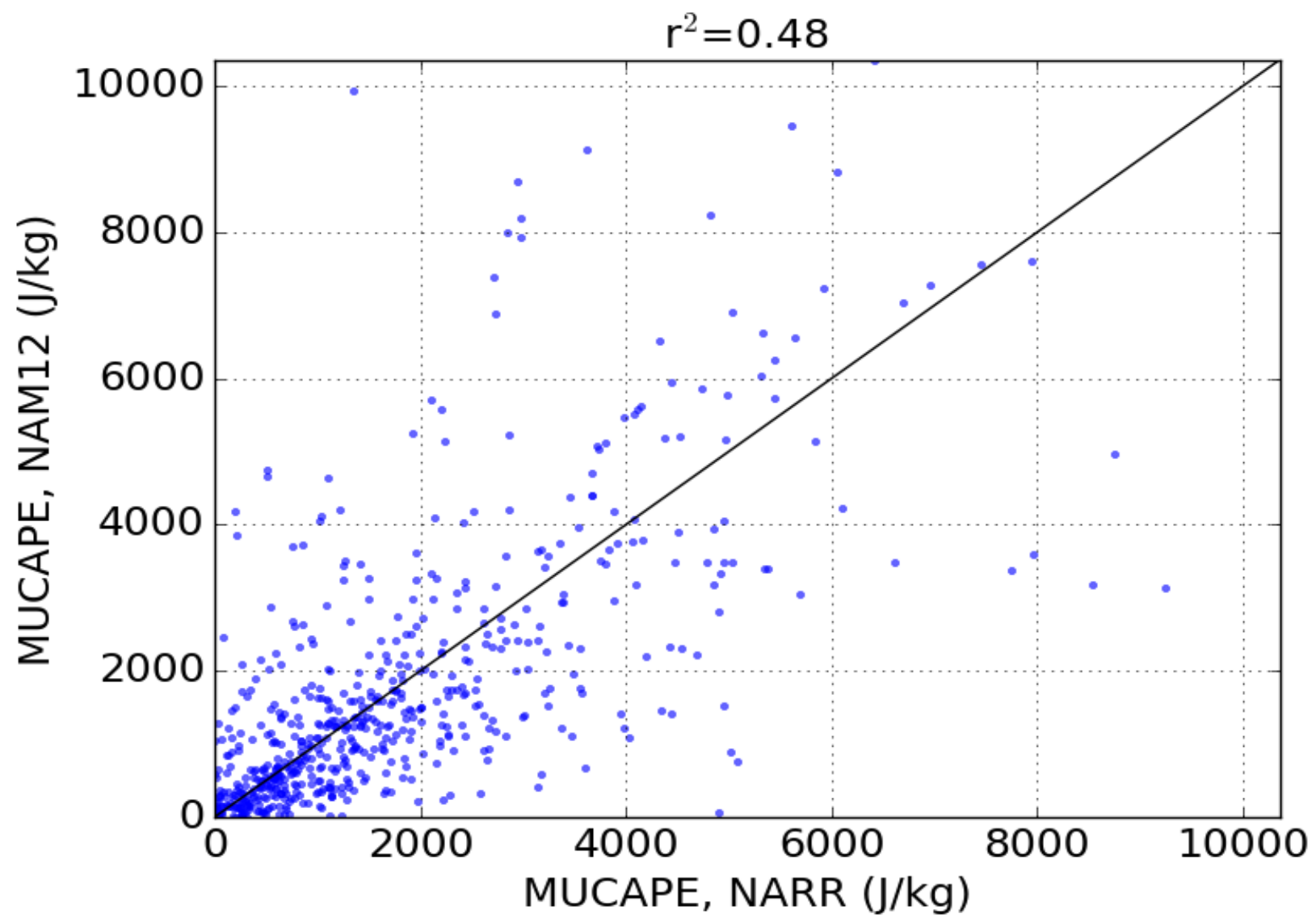


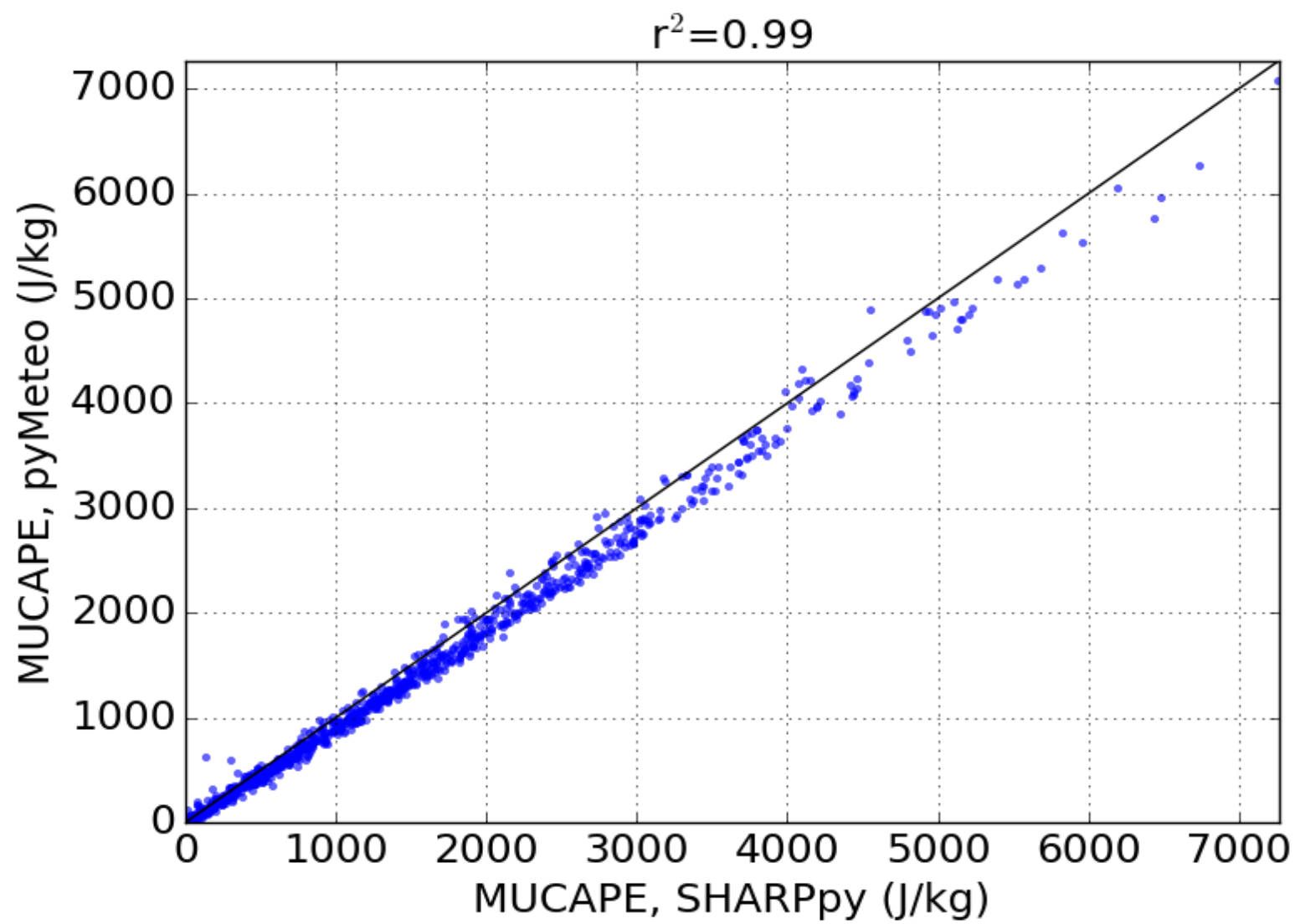


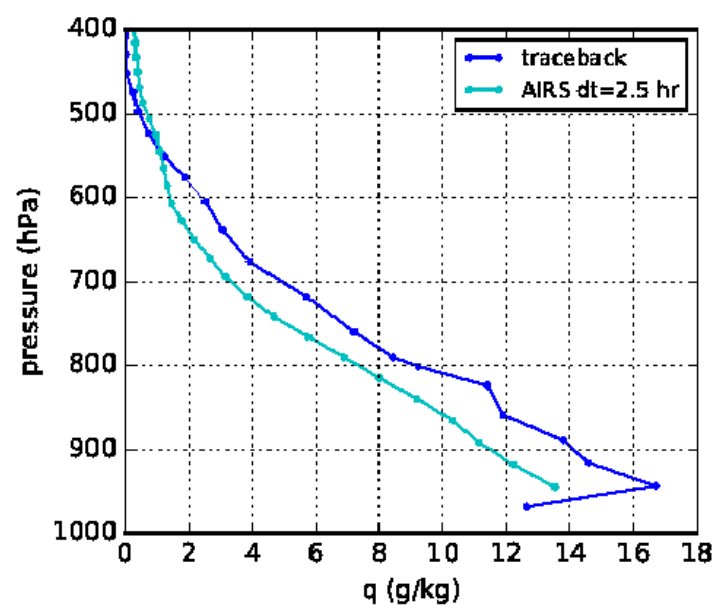
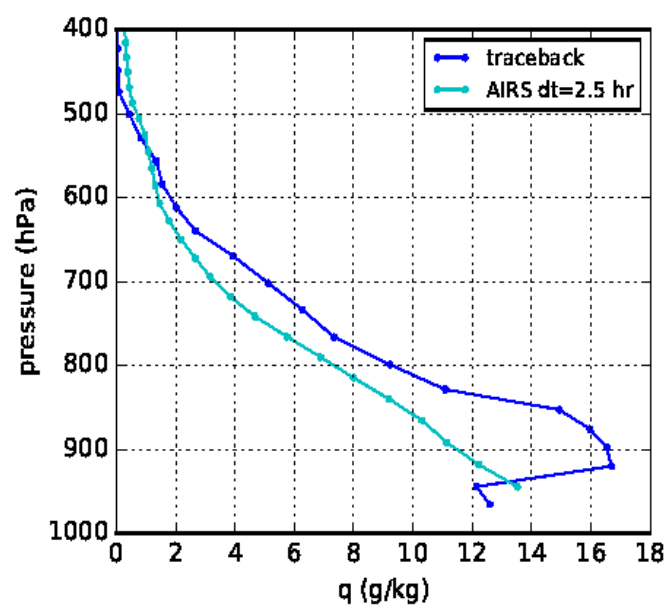
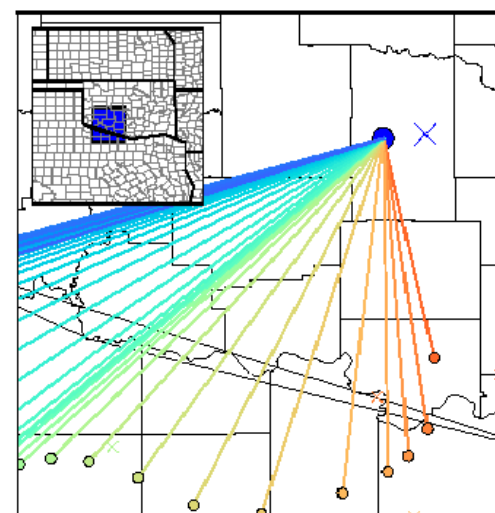
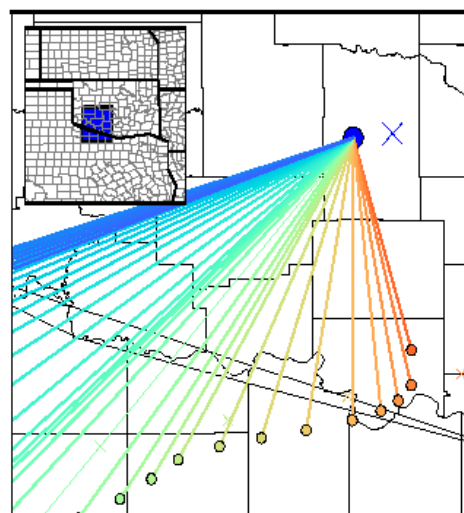


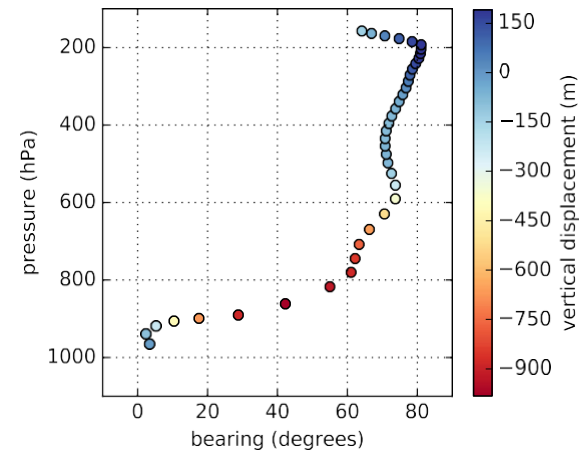
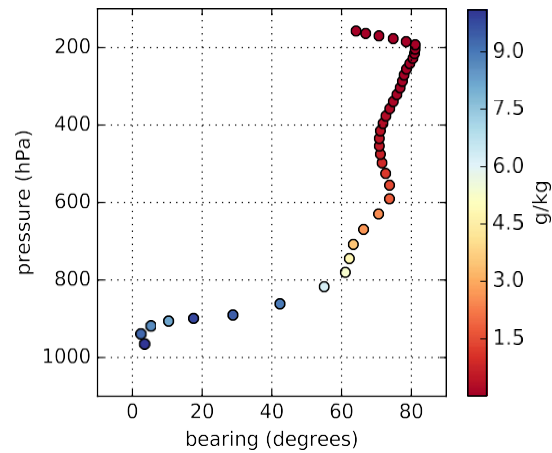
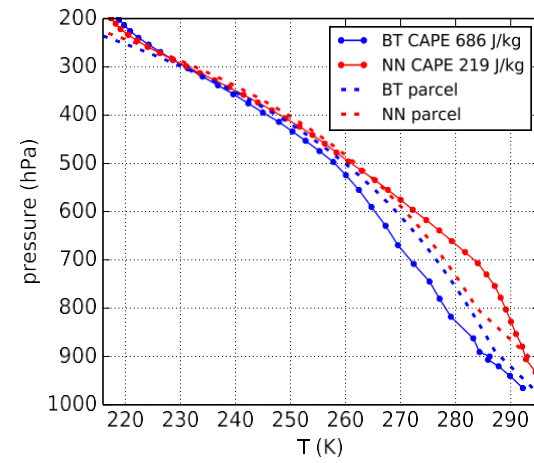
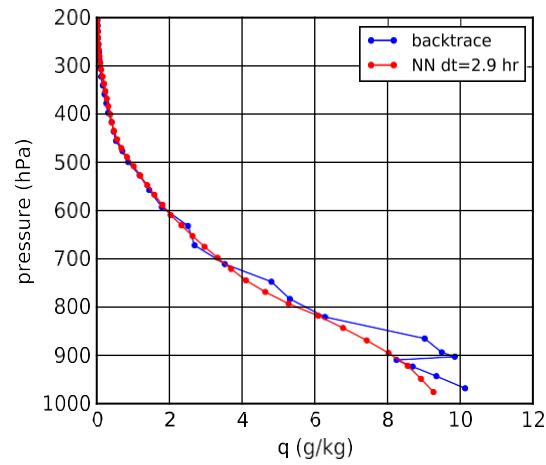
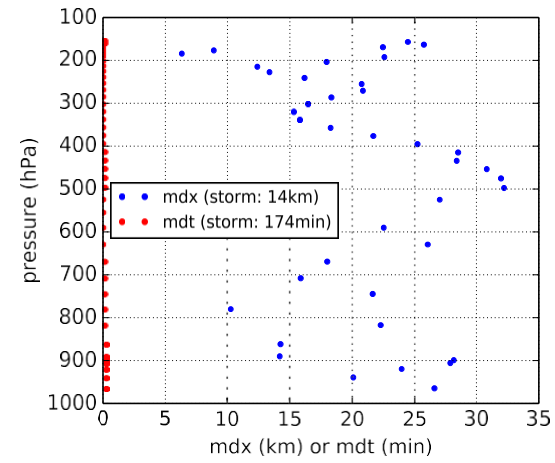
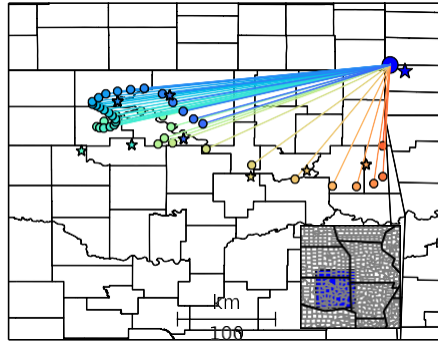


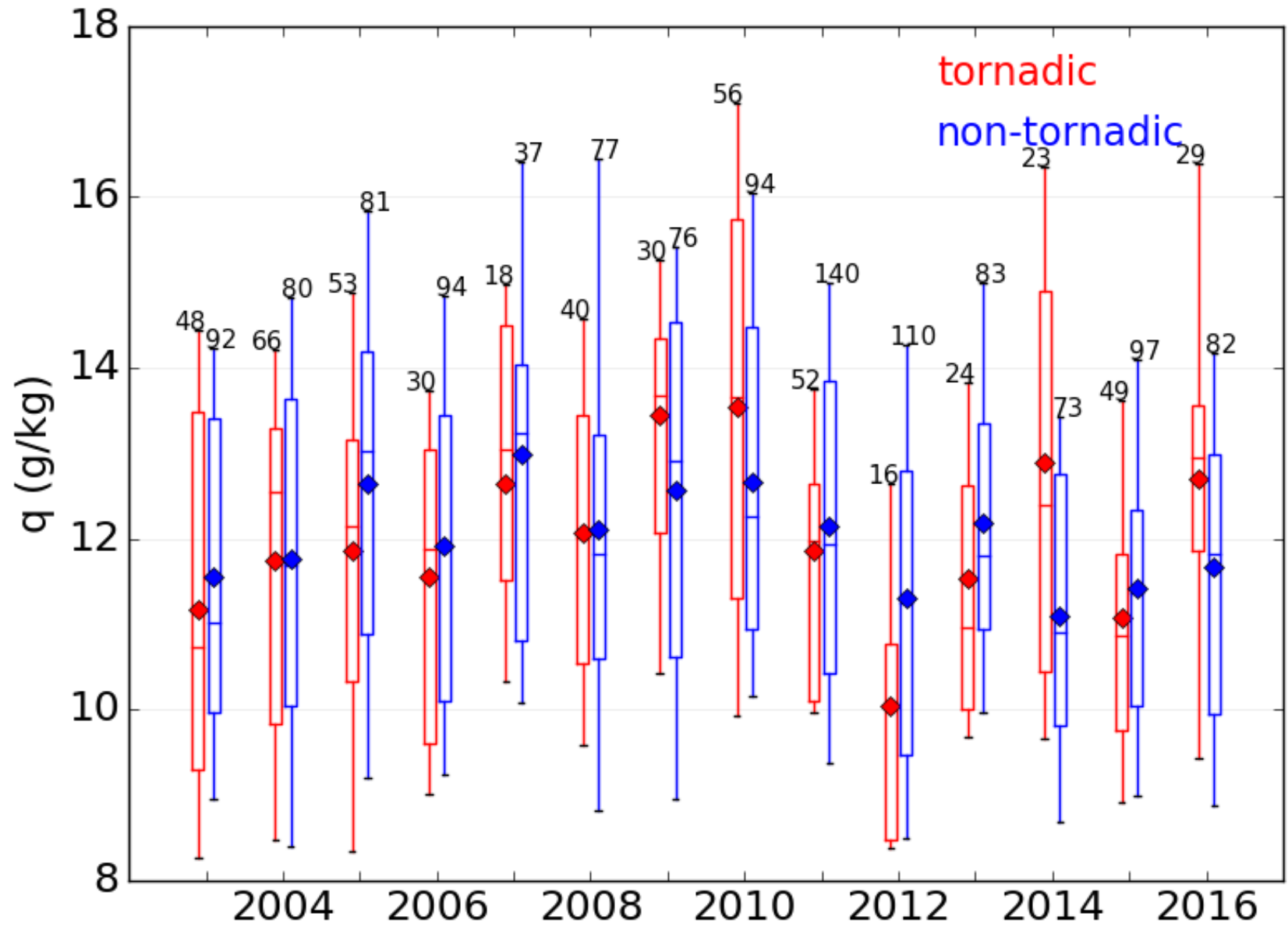


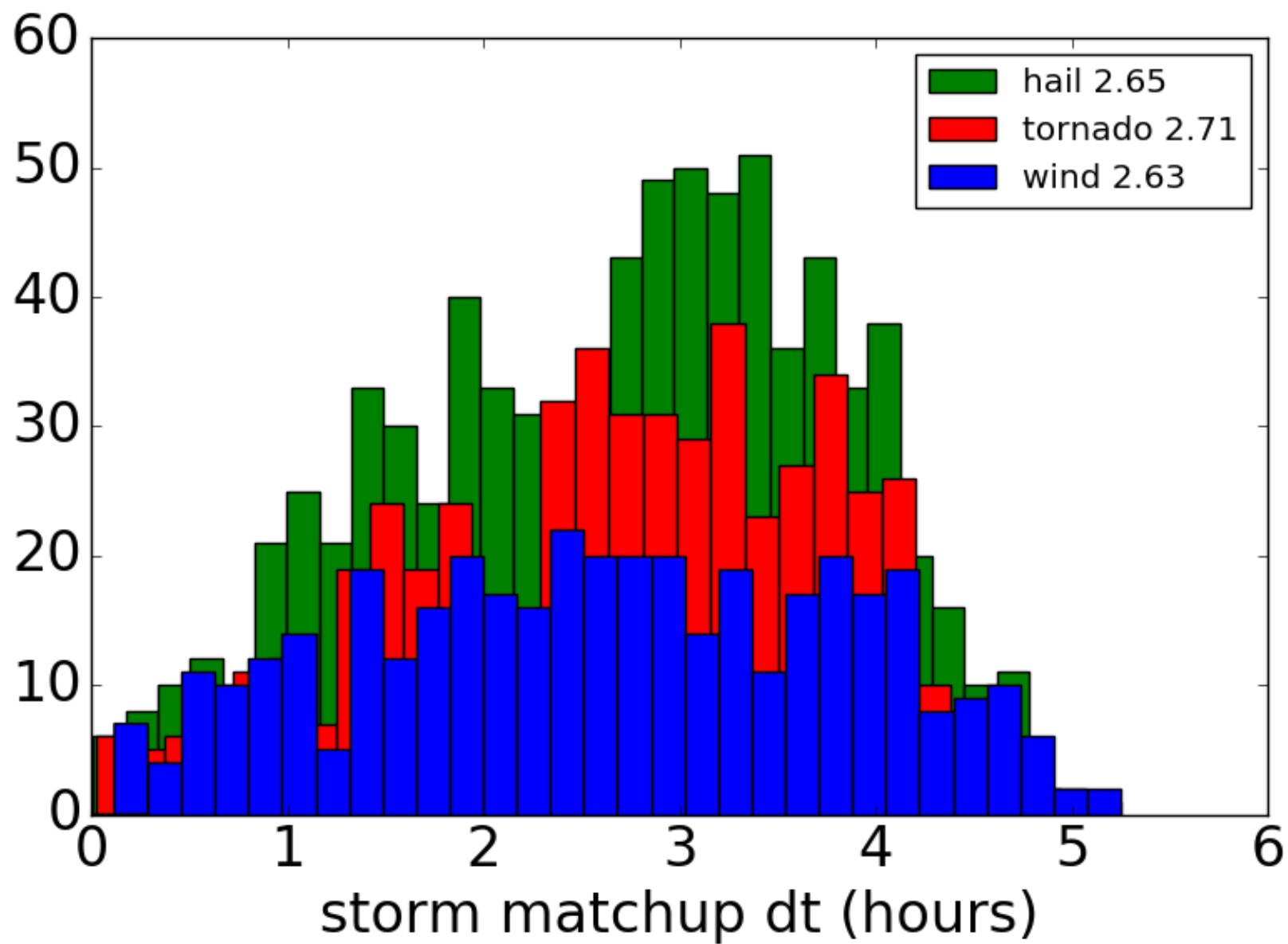








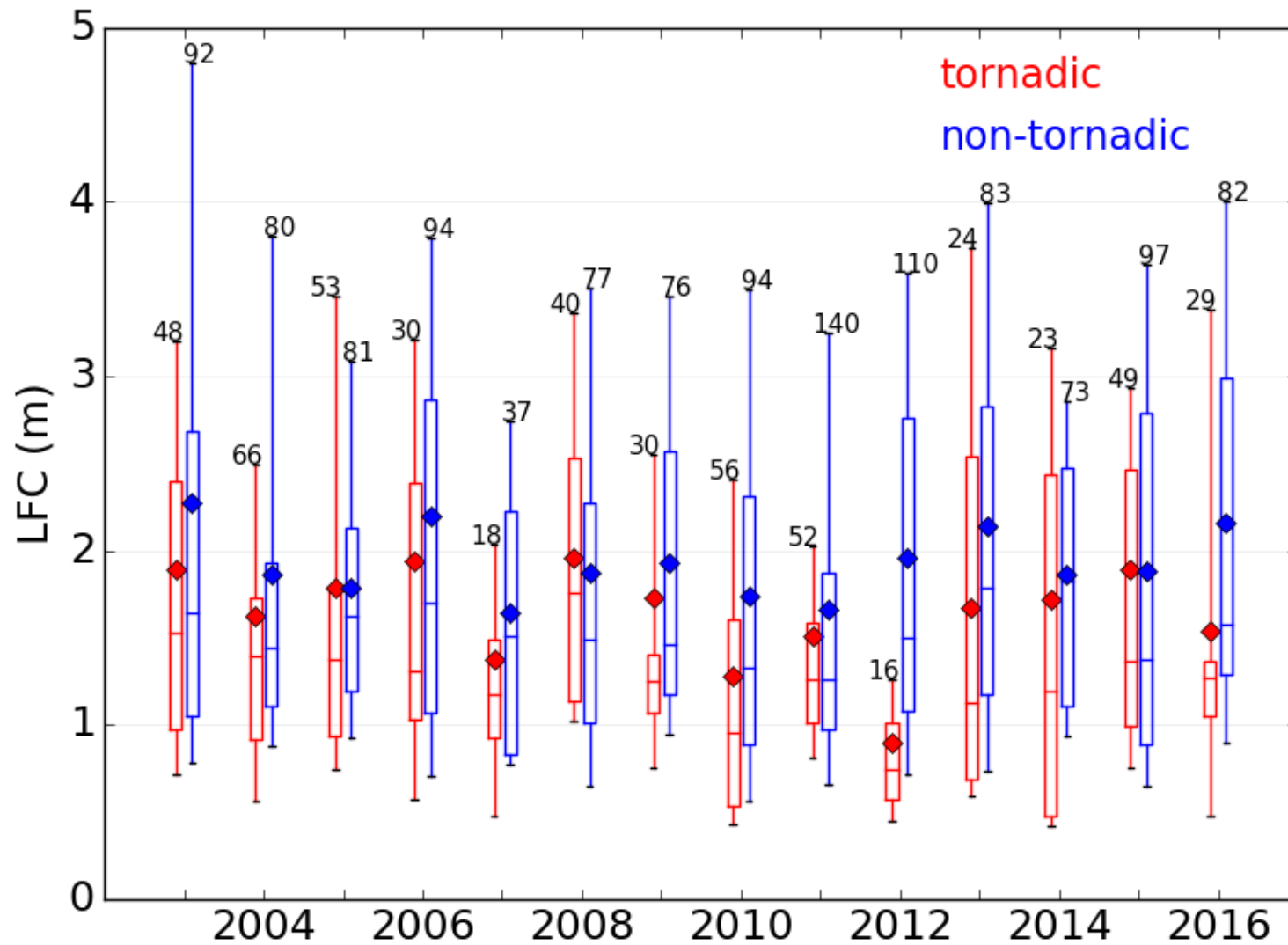




Attrition of storm reports within the analysis pipeline, from an input of 25,820 initial storm reports, for the NARR meteorology over the entire AIRS record.

<u>Reason for exclusion</u>	<u>Percent of input</u>
Storm before overpass	30.7
HYSPLIT lost backtrace level(s)	10.6
No NN matchup	29.9
No matchup for at least one level	8.2
DQ2 in at least one level	14.3
CAPE = 0, NN or backtrace	2.3

Annual variability in LFC



Annual variability in CAPE

